

Assignment 3

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Q1

a)

Our original 'non-model' is:

$$z - z_0 = a((x - x_0)^2 + (y - y_0)^2)$$

We can rewrite our new linear model as:

$$z = A_0(x^2 + y^2) + A_1 x + A_2 y + A_3$$

The relation between new parameters and old parameters:

$$A_0 = a$$

$$A_1 = -ax_0$$

$$A_2 = -ay_0$$

$$A_3 = ax_0^2 + ay_0^2 + z_0$$

b) & c)

```
In [35]: runfile('D:/文档/GitHub/general/phys512_Assignment_3/q1.py',
wdir='D:/文档/GitHub/general/phys512_Assignment_3')
RMS scatter about model is 3.768338648784731
parameter 0 has value 0.00016670445477399501 and error
6.451899757263445e-08
parameter 1 has value 0.00045359902596291336 and error
0.00012506109951270796
parameter 2 has value -0.01941155886649398 and error
0.00011924956427610129
parameter 3 has value -1512.3118166739064 and error
0.3120184362020161
The focal length is 1.499659984125383 meters
```

The **RMS** scatter about model is **3.768338648784731**.

With SVD, I got my **parameters** and their **errors**:

$$A_0 = 1.66704455e-04 \pm 6.451899757263445e-08$$

$$A_1 = 4.53599026e-04 \pm 0.00012506109951270796$$

$$A_2 = -1.94115589e-02 \pm 0.00011924956427610129$$

$$A_3 = -1.51231182e+03 \pm 0.3120184362020161$$

So the **uncertainty** in **a** is 6.451899757263445e-08. The focal length I got is **1.499659984125383**

Q2

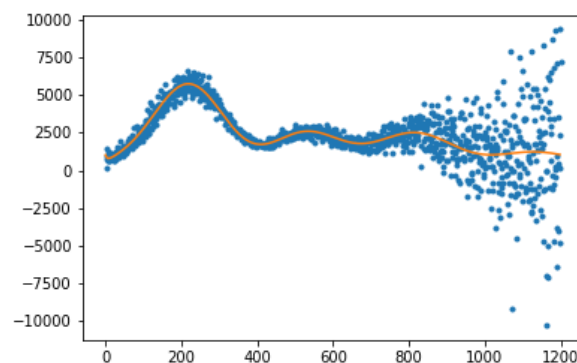
```
def get_spectrum(pars,y,lmax=2000):
    #print('pars are ',pars)
    H0=pars[0]
    ombh2=pars[1]
    omch2=pars[2]
    tau=pars[3]
    As=pars[4]
    ns=pars[5]
    pars=camb.CAMBparams()
    pars.set_cosmology(H0=H0,ombh2=ombh2,omch2=omch2,mnu=0.06,omk=0,tau=tau)
    pars.InitPower.set_params(As=As,ns=ns,r=0)
    pars.set_for_lmax(lmax,lens_potential_accuracy=0)
    results=camb.get_results(pars)
    powers=results.get_cmb_power_spectra(pars,CMB_unit='muK')
    cmb=powers['total']
    tt=cmb[2:len(y)+2,0] #remove first two entries
    return tt
```

The first two entries of CAMB returns were manually remove. The columns of data text file were loaded in correctly. The chi square I got from this step is as expected, **1588.237653293156**

```
In [1]: runfile('C:/Users/123/Documents/GitHub/general/phys512_Assignment_3/
q2.py', wdir='C:/Users/123/Documents/GitHub/general/phys512_Assignment_3')
chi square is 1588.2376532931526
```

Q3

```
The optimal parameters with fixed tau are [6.93273628e+01
2.24913866e-02 1.13912177e-01 2.04250508e-09
9.69769630e-01]
Their errors with fixed tau are [2.40199384e+00 5.39631337e-04
5.22686895e-03 3.89837813e-11
1.35886316e-02]
Their errors when floating tau are [3.66690233e+00 8.50022991e-04
7.03682703e-03 1.49331220e-01
5.93553054e-10 2.61963172e-02]
The final chi square is 1227.9356355960042
```



It looks like it is doing a good job. Luckily, with Newton's method, the final **chi square** is improved and down to 1227.9356355960042.

The optimal parameters with fixed tau are:

6.93273674e+01
2.24913878e-02
0.05
1.13912169e-01
2.04250500e-09
9.69769637e-01

Their errors with fixed tau are:

2.40199240e+00
5.39627332e-04
5.22687090e-03
3.89839951e-11
1.35886726e-02
1.49331227e-01

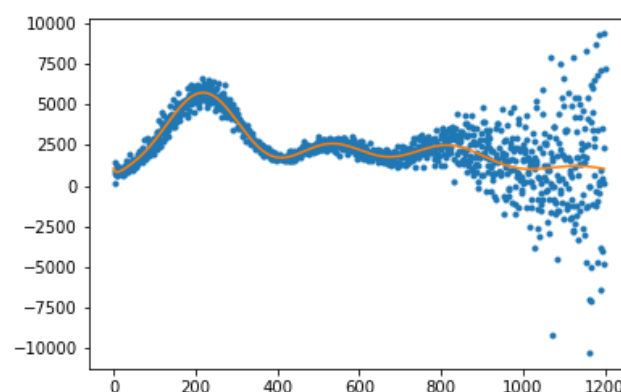
Their errors when floating tau are:

3.66690095e+00
8.50018389e-04
7.03682738e-03
1.49331227e-01
5.93553400e-10
2.61963951e-02

It seems that the errors of other parameters **increase** when floating the tau.

Q4

```
Fitted parameters are [6.72947824e+01  
2.19568596e-02 1.16627504e-01 5.19667716e-02  
2.05303345e-09 9.53473039e-01]  
Their errors are [2.94287678e+00  
5.59265857e-04 7.00276306e-03 1.98053803e-02  
5.83914014e-11 1.51134610e-02]  
The chi square is 1229.5336197961765
```



Fitted parameters are:

6.72947824e+01
2.19568596e-02

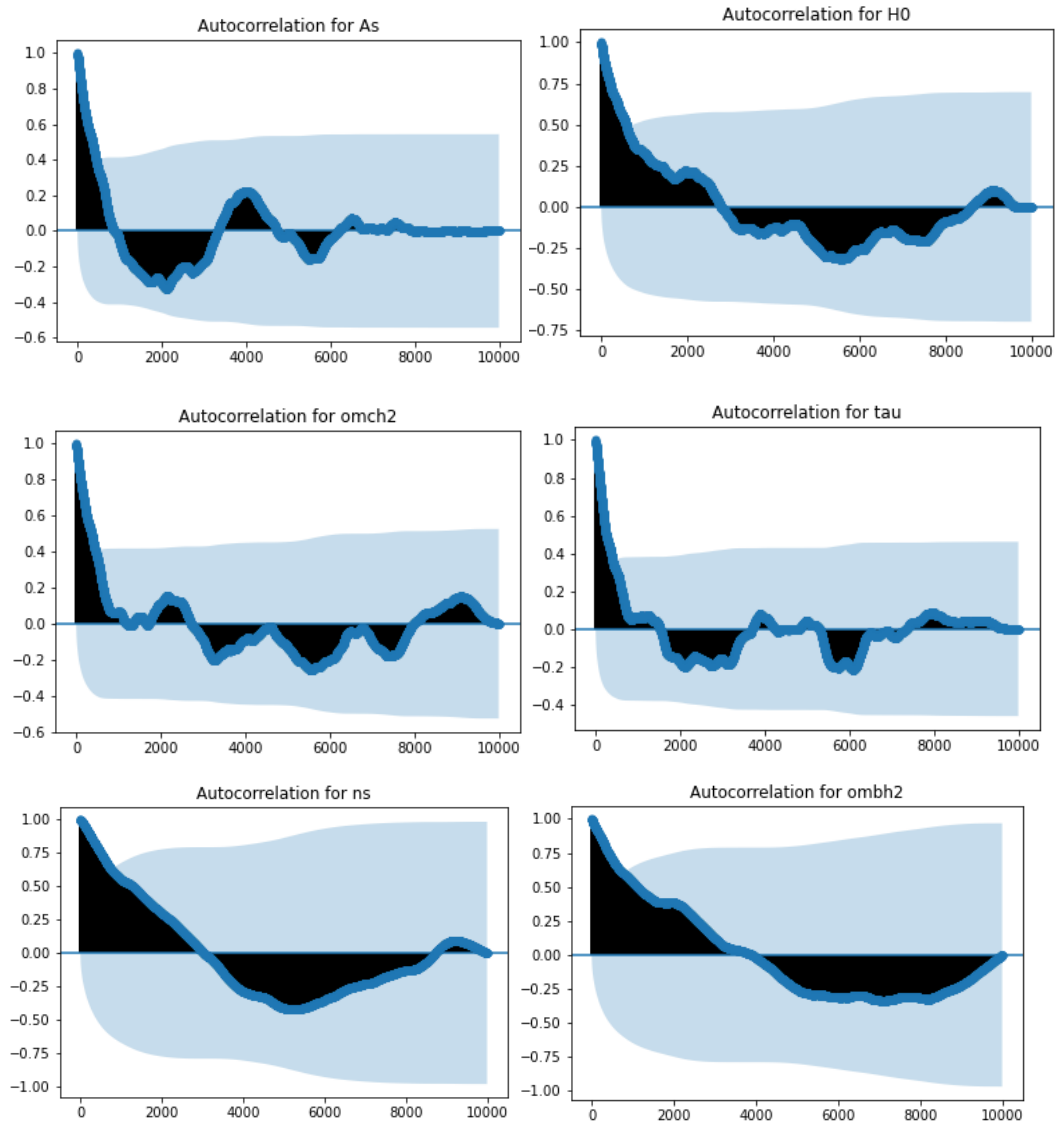
1.16627504e-01
5.19667716e-02
2.05303345e-09
9.53473039e-01

Their errors are:

2.94287678e+00
5.59265857e-04
7.00276306e-03
1.98053803e-02
5.83914014e-11
1.51134610e-02

The chi square is 1229.5336197961765

To ensure my parameters are converged, I plot the **autocorrelation plot** for each of my parameter. **Them seem all converged.**

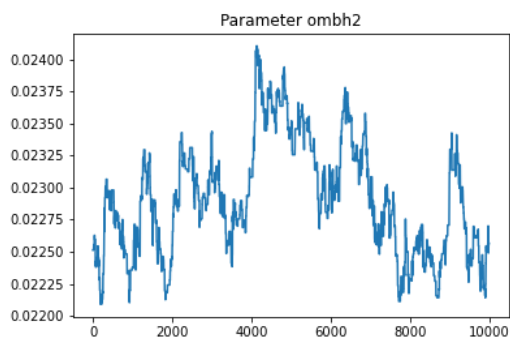
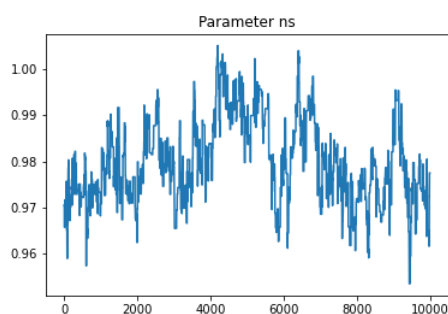
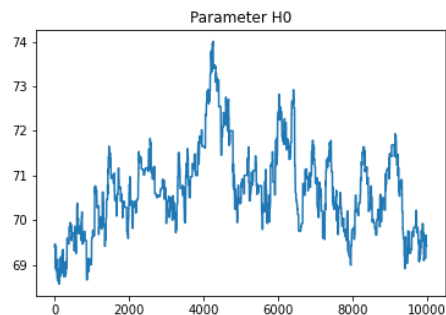
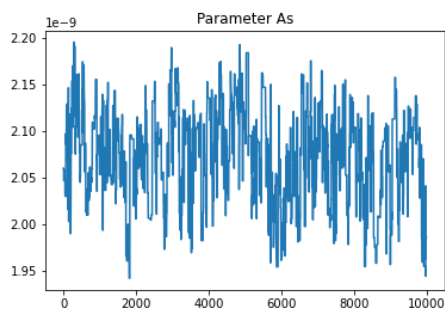


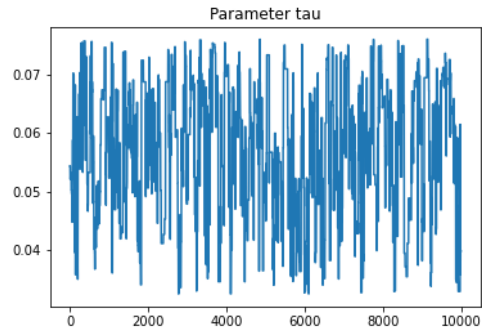
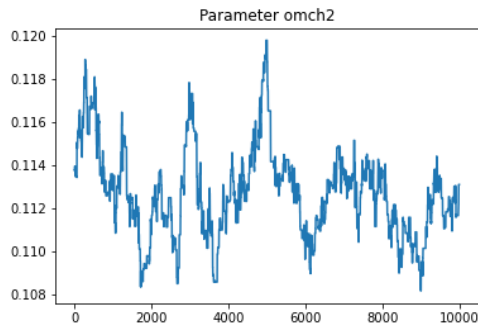
Q5)

The results from new chain with the prior for $0.0544 - 3 \cdot 0.0073 < \tau < 0.0544 + 3 \cdot 0.0073$ (three sigmas) are:

```
Fitted parameters are [7.06762533e+01  
2.29105023e-02 1.12731074e-01 5.69868024e-02  
2.07298875e-09 9.79702975e-01]  
Their errors are [9.63889972e-01 4.43851725e-04  
2.06253778e-03 1.14488665e-02  
5.18414329e-11 9.18904467e-03]  
The chi square is 1228.5117530204197
```

Here are all the traces of the parameters with 10000 steps:





The results by importance sampling are:

```
By important sampling from the old chain, the amparameters
are [6.72530126e+01 2.19073612e-02 1.16420083e-01
5.51719391e-02
2.06180935e-09 9.52151503e-01]
Error in parameters= [2.58868684e+00 5.40987936e-04
5.74875606e-03 6.84832730e-03
4.04958891e-11 1.58056662e-02]
```

Compare to the results from the new chain, importance sampling gives larger errors on parameters and the mean of the parameters are a little bit different from the new chain's means.

FT for All the parameters show that they are **all converged**:

